Environmental Levies and Distortionary Taxation

By A. Lans Bovenberg and Ruud A. de Mooij*

In the face of growing concerns about serious environmental problems, environmental taxes have attracted increasing attention. Many economists have argued that pollution levies are an efficient instrument for achieving environmental objectives (see e.g., William J. Baumol and Wallace E. Oates, 1988). Some have gone even further to suggest that environmental taxes may yield benefits over and above a cleaner environment. In particular, governments can use the revenues from pollution taxes to decrease other, distortionary taxes. In this way, environmental taxes may yield a "double dividend"—not only a cleaner environment, but also a less distortionary tax system. This argument suggests that one may wish to push the role of environmental taxes beyond that of solely an instrument for environmental protection and employ these instruments also as a revenue-raising device (see e.g., Oates, 1991). Furthermore, if pollution taxes are available, ambitious environmental policies may seem more attractive if public revenues become scarcer. Indeed, high estimates for the deadweight losses of current tax systems have been used to suggest that environmental taxes may yield important "side benefits" (see e.g., Oates, 1991; David W. Pearce, 1991).

The main contribution of this note is to show that environmental taxes typically exacerbate, rather than alleviate, preexisting tax distortions—even if revenues are employed to cut preexisting distortionary taxes. We demonstrate that, in the presence of preexisting distortionary taxes, the optimal pollution tax typically lies below the Pigovian tax, which fully internalizes the marginal social damage from pollution. Intuitively, the collective good of environmental quality directly competes with other collective goods. Hence, the marginal costs of environmental policy rise with the marginal cost of public funds.

I. The Model

A linear technology describes production:

$$(1) \qquad hNL = NC + ND + G.$$

Labor, L, is the only input into production. Labor productivity, h, is constant, while output can be used for public consumption, G, as well as for the consumption of clean and dirty private consumption commodities denoted by, respectively, C and D. We normalize units so that the constant rates of transformation between the three produced commodities are unity. All private commodities are expressed in per capita terms. N stands for the number of households.

Two public goods enter household utility $U = u(C, D, V, G, E)$, namely, public consumption and environmental quality, E. The household takes the supply of both of these goods as given. Hence, in optimizing its utility, the household adopts as instruments the demands for private goods (i.e., leisure [V] and clean and dirty consumption). By including the quality of the natural environment in the utility function, we are able to perform explicit welfare analysis, and in particular, we can examine the interaction between environmental and labor-market distortions in a second-best framework. The

*Bovenberg: CentER for Economic Research, Tilburg University, P.O. Box 90153, 5000 LE Tilburg, Netherlands, Research Centre for Economic Policy (OCFEB), Erasmus University Rotterdam, and Centre for Economic Policy Research, London; de Mooij: Ministry of Economic Affairs, Netherlands, and Research Centre for Economic Policy (OCFEB), Rotterdam, Netherlands. The views expressed in this note are strictly personal. They do not necessarily represent the official positions of the Ministry of Economic Affairs in the Netherlands. We thank three anonymous referees for constructive comments on earlier drafts.

environmental distortion comes about because households do not take into account the adverse effect of their dirty consumption on environmental quality $E = e(ND)$; $de/d(ND) < 0$. The labor-market distortion originates in a tax on labor income. This tax is distortionary, as the model allows for endogenous labor supply by including leisure, V, in utility. The household-budget constraint amounts to

$$(2)\quad C + (1 + t_D)D = h(1 - t_L)(1 - V)$$

where t_L denotes the ad valorem tax rate on labor income and t_D stands for the pollution tax on dirty consumption. The labor endowment is normalized at 1 (hence, $V + L = 1$).

The law of Walras yields the government budget constraint by combining market equilibrium (1) and the household-budget constraint (2):

$$(3)\qquad G = t_D ND + t_L hNL.$$

The welfare effects of a revenue-neutral change in the tax mix (i.e., $dG = 0$) are found from

$$(4)\quad dU = -\frac{\partial u}{\partial V}dL + \frac{\partial u}{\partial C}dC + \frac{\partial u}{\partial D}dD + \frac{\partial u}{\partial E}\left[\frac{de}{d(ND)}\right]NdD.$$

Substituting the first-order conditions characterizing optimal household behavior and using (1), we arrive at the following:

$$(5)\quad \frac{dU}{\lambda} = ht_L\,dL + \left[t_D - N\frac{\partial u}{\partial E}\left(-\frac{de}{d(ND)}\right)\Big/\lambda\right]dD$$

where λ denotes marginal utility of income. The first term on the right-hand side of (5) stands for the effect on the labor-market distortion, which is due to the tax on labor income. The second term corresponds to the effect on the environmental distortion. The welfare impact of a marginal increase in dirty consumption amounts to the difference between a tax term, which measures the social benefits of additional tax revenue due to a wider revenue base, and a term representing the marginal social damage from pollution. In the absence of a pollution levy (i.e., $t_D = 0$), cutting the demand for the dirty commodity enhances overall welfare because the social costs of pollution exceed the social benefits.

In the "first-best" case, in which there is no need to finance public spending through distortionary taxation (i.e., $t_L = 0$), the optimal value of t_D would simply be the Pigovian tax. This tax fully internalizes the adverse external effects of pollution:

$$(6)\qquad t_D = N\frac{\partial u}{\partial E}\left(-\frac{de}{d(ND)}\right)\Big/\lambda.$$

At the Pigovian tax, the beneficial environmental effects associated with less dirty consumption would exactly offset the adverse welfare effects due to an erosion of the tax base. Changes in employment would not affect welfare; in the absence of distortionary labor taxation, the social opportunity costs of additional employment exactly offset the social benefits. In the presence of a distortionary tax on labor ($t_L > 0$), however, the optimal environmental tax depends on the response of employment to a change in the tax mix.

II. Employment

In order to explore the general-equilibrium impact of a higher pollution tax on employment, the model is log-linearized.[1] A tilde (~) denotes a relative change, unless indicated otherwise. Since we explore a change in the tax mix, we assume that the government does not change public consumption (i.e., $\tilde{G} = 0$). Log-linearizing the

[1]This approach amounts to an exercise in comparative statics. For a similar approach, see Wouter J. Keller (1980) and Bovenberg (1989).

government budget constraint (3) and dividing through by $(1-t_L)hNL$, we find

$$\tilde{b}^t = -\tilde{t}_L - \Phi_D \tilde{t}_D. \tag{7}$$

Φ_D denotes the share of dirty goods in overall household consumption: $\Phi_D = (1+t_D)D/[C+(1+t_D)D]$; $\tilde{t}_L$ and $\tilde{t}_D$ are defined as $\tilde{t}_L = dt_L/(1-t_L)$ and $\tilde{t}_D = dt_D/(1+t_D)$. The "tax-base" effect is defined by

$$\tilde{b}^t \equiv \frac{\left[t_L \tilde{L} + t_D a_D \tilde{D}\right]}{1-t_L} \tag{8}$$

where $a_D = (D/hL) = (1-t_L)\Phi_D/(1+t_D)$ is the output share of dirty goods. The two terms in square brackets in (8) stand for the effects on the bases of the labor tax and the pollution levy, respectively. Given a fixed before-tax wage, h, the right-hand side of (7) stands for the relative change in the after-tax real wage, $w = h(1-t_L)/p$, where p is the consumption price index:

$$\tilde{w} = -\tilde{t}_L - \Phi_D \tilde{t}_D. \tag{9}$$

Hence, expression (7) reveals that the real after-tax wage falls if the tax base erodes (i.e., $\tilde{b}^t < 0$).

In order to find expressions for household labor supply, $\tilde{L}$, and demand for dirty goods, $\tilde{D}$, we make some separability assumptions regarding household utility:

$$U = u(G, E, H(V; Q(C,D))). \tag{10}$$

Private goods are (weakly) separable from public goods G and E. Environmental quality and public consumption thus do not directly affect private demand. The subutility function Q aggregates clean and dirty consumption into a composite consumption good, Q. This function is homothetic. Hence, in the absence of environmental externalities, a uniform tax on clean and dirty consumption would be optimal. Optimizing utility (10) subject to the household budget constraint (2), we find labor supply:

$$\tilde{L} = \theta_\ell \tilde{w} \tag{11}$$

where $\theta_\ell = V\sigma_V - V$ stands for the uncompensated wage elasticity of labor supply. The substitution effect dominates the income effect if the substitution elasticity between leisure and composite consumption, σ_V, exceeds unity. Labor supply depends only on the after-tax real wage. Neither the price of dirty goods nor environmental quality enters expression (11) because of the separability assumptions implicit in (10).

The following expression describes household demand for dirty consumption:

$$\tilde{D} = \tilde{L} + \tilde{w} - (1-\Phi_D)\sigma \tilde{t}_D \tag{12}$$

where σ represents the substitution elasticity between clean and dirty consumption in the subutility function $Q(C,D)$. The solution for employment is derived by substituting (8), (9), (11), and (12) into (7):

$$\Delta \tilde{L} = -\theta_\ell t_D a_D (1-\Phi_D)\sigma \tilde{t}_D \tag{13}$$

where $\Delta \equiv 1-(t_L + a_D t_D)(1+\theta_\ell) > 0$.[2] An increase in the pollution tax from a positive initial level (i.e, $t_D > 0$) reduces employment if the uncompensated wage elasticity of labor supply, θ_ℓ, is positive. We assume that the labor-supply curve is indeed upward-sloping, as most empirical studies yield positive estimates for this elasticity (see e.g., Jerry Hausman, 1985). The negative effect on employment is due to a decline in the real after-tax wage eroding the incentives to supply labor. The drop in the real after-tax wage comes about because the lower tax rate on labor income does not fully compensate workers for the adverse effect of the pollution levy on their real after-tax wage. This incomplete offset is due to the erosion of the base of the environmental tax. In particular, the higher environmental tax induces households to switch from dirty to clean consumption commodi-

[2] If $\Delta < 0$, the Laffer curve is downward-sloping, and the model is not stable.

ties. If the initial tax rate on the dirty commodities is positive, this behavioral effect erodes the base of the environmental tax and, therefore, produces a negative tax-base effect (i.e., $\tilde{b}^t < 0$). Expressions (7) and (9) indicate that this reduces the real after-tax wage. Thus, if it needs to maintain overall tax revenues, the government is unable to reduce the labor tax sufficiently to offset the adverse effect of the higher pollution levy on the real after-tax wage. The resulting lower income from an additional unit of work erodes the incentives to supply labor.

Intuitively, as an instrument to finance public spending with the least costs to after-tax wages, the environmental tax, which amounts to a narrow-based tax, is less efficient than a broad-based labor tax because, in contrast to a labor tax, it "distorts" the composition of the consumption basket. These "distortions" enhance environmental quality but reduce the real after-tax income from work. Whereas the environmental benefits are public and independent of the amount of labor supplied, the costs depend on the amount of labor supplied. Indeed, by enhancing environmental quality, pollution taxes expand the overall supply of collective goods. This reduces the incentives to supply labor because the costs of all collective goods, including a cleaner environment, are borne by labor.

III. Optimal Pollution Tax

Armed with the general-equilibrium effects on employment, we can now return to expression (5) for the welfare effects of marginal tax changes. Without a preexisting distortionary tax (i.e., $t_L = 0$), welfare would not be affected if the government were to marginally reduce the environmental tax below its Pigovian level. If the initial tax on labor is positive ($t_L > 0$), in contrast, welfare would increase. Whereas the second term on the right-hand side of (5) would be zero, the rise in employment associated with a lower pollution tax would produce a positive first term. In this "second-best" case with distortionary taxation, therefore, the optimal environmental tax lies below the social damage from pollution.

In this way, high costs of public funds crowd out not only ordinary public consumption, but also the collective good of the environment. Following Anthony B. Atkinson and Nicholas H. Stern (1974) and David E. Wildasin (1984), Charles L. Ballard and Don Fullerton (1990) explore the conditions under which distortionary taxation crowds out public spending by raising the marginal cost of public funds above unity (i.e., the marginal costs of public funds in a first-best economy with lump-sum taxes). For public spending that is separable from consumers' choices on leisure and consumption, they derive that distortionary labor taxes raise the marginal costs of public spending above unity if the uncompensated wage elasticity of labor supply is positive. We find that the same condition on the uncompensated wage elasticity determines whether distortionary labor taxes raise the marginal cost of (the collective good of) environmental protection above its social benefit. This result depends on the separability assumptions regarding utility. If environmental quality were a closer substitute for private consumption than for leisure, a heavier reliance on environmental taxes would imply smaller income effects on labor supply. In the extreme case in which households would perceive an improvement in environmental quality as cash, compensated rather than uncompensated elasticities would govern the effect on the marginal cost of environmental protection (see Wildasin, 1984).

The government can use the revenues from pollution taxes to raise lump-sum transfers rather than to cut labor taxes. The associated higher levels of distortionary taxation and transfers imply that employment would decline more than in the case in which labor taxes are cut.[3] The lower level

[3]Note that the compensated wage elasticity of labor supply determines the employment impact of using labor taxes to raise income transfers. The reason is that the additional transfers offset the income effects of higher labor taxes. Hence, only the substitution effect of higher labor taxes remains.

of employment erodes the base of the labor tax, thereby further worsening preexisting tax distortions. In the presence of distortionary taxes, therefore, pollution taxes become more attractive if the revenues are not recycled in a lump-sum fashion, but rather are used to cut distortionary taxes.[4] Hence, there exists a "doubled dividend" in the sense that a cost reduction can be achieved by using revenues from pollution taxes to cut distortionary taxes rather than returning these revenues in a lump-sum fashion.

[4]If the government uses environmental policy instruments that do not yield public revenues, it in effect distributes free pollution rights to the private sector. These free pollution rights amount to a lump-sum transfer. For a formal analysis, see Bovenberg and de Mooij (1993).

REFERENCES

Atkinson, Anthony B. and Stern, Nicholas H. "Pigou, Taxation and Public Goods." *Review of Economic Studies*, January 1974, *41*(1), pp. 119–28.

Ballard, Charles L. and Fullerton, Don. "Wage Tax Distortions and Public Good Provision." National Bureau of Economic Research (Cambridge MA) Working Paper No. 3506, 1990.

Baumol, William J. and Oates, Wallace E. *The theory of environmental policy*. Cambridge: Cambridge University Press, 1988.

Bovenberg, A. Lans. "The Effects of Capital Income Taxation on International Competitiveness and Trade Flows." *American Economic Review*, December 1989, *79*(5), pp. 1045–64.

Bovenberg, A. Lans and de Mooij, Ruud A. "Environmental Policy in a Small Open Economy with Distortionary Labor Taxes: A General Equilibrium Analysis." Mimeo, Research Centre for Economic Policy (OCFEB), Erasmus University, Rotterdam, 1993.

Hausman, Jerry A. "Taxes and Labor Supply," in Alan J. Auerbach and Martin S. Feldstein, eds., *Handbook of public economics*, Vol. 1. Amsterdam: North-Holland, 1985, pp. 213–63.

Keller, Wouter J. *Tax incidence: A general equilibrium approach*. Amsterdam: North-Holland, 1980.

Oates, Wallace E. "Pollution Charges as a Source of Public Revenues." Discussion Paper No. QE92-05, Resources for the Future, Washington, DC, 1991.

Pearce, David W. "The Role of Carbon Taxes in Adjusting to Global Warming." *Economic Journal*, July 1991, *101*(407), pp. 938–48.

Wildasin, David E. "On Public Good Provision with Distortionary Taxation." *Economic Inquiry*, April 1984, *22*(2), pp. 227–43.